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Troubleshooting the CAN I/O bus with SMC-42.

Troubleshooting sporadic errors on the CAN I/O bus is relatively difficult and time consuming. These instructions provide information on the various possible techniques that have proven useful in practice.

Troubleshooting measures are suggested here.

If the CAN I/O bus is functioning correctly, you will not find any error messages in the CAN statistics in the service mode. The service mode can be opened from the manual mode and the statistical data for each CAN I/O module viewed.

On the occurrence of problems, the analogue signals on the CAN bus should be checked and analysed with a CRO.

The SMC-42 program must be checked for correctness or modified for specific test methods.

Measurements on cables, screening and terminating resistors are very important.

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1 Selecting service mode

The statistics on all CAN I/O modules that have been declared in the .CAN_DEVICE table can be opened in the service mode. You can only switch to the service mode from the manual mode.
To start the service mode, press the SHIFT and 6 keys in succession.
The ESC, MAN and STAT LEDs illuminate to display the service mode.
To open the statistics on the CAN I/O modules, press the RIGHT (>) key.

The statistics for the first module in the .CAN_DEVICE table are displayed. E.g.:

```
SERV left,right,exit with ESC

UP/DOWN 1, HIGH/LOW 10
INDEX =  0
IDENT =  4
M_ERR =  0
MESGS =  543211
REPEAT=  0
EMERG =  0
```

You can access the next or previous I/O module or its I/O group in steps of 1 using the UP and DOWN keys.
Using the HIGH and LOW keys you can access the next or previous I/O module or its I/O group in steps of 10.
The I/O group is identical to the module for the module types T0, T1 and T4.
Module type T2 has 3 I/O groups because it contains 24 outputs. Each I/O group represents one I/O byte. The only difference is the higher INDEX with the same identifier ID. The INDEX is formed on the initialisation of the CAN I/O bus as per the sequence of the modules in the .CAN_DEVICE table and is incremented for each I/O group.

IDENT is the identifier for the indexed I/O group.
M_ERR is the maximum number of the same messages that have been repeated for the related I/O group. These error messages are sent by the I/O group if the outputs have been overloaded or short-circuited.
MESGS is the total number of outgoing messages to the related I/O group since the CAN I/O bus was switched on using the CAN_ON command.
REPEAT is the total number of repeated messages.
EMERG is the total number of error messages for the related I/O group if the I/O module was not able to synchronise itself on the CAN I/O bus.

M_ERR, REPEAT and EMERG must be equal to ZERO for correct operation!

On all modules with version 1, 2 or 3 (year of manufacture 1999) REPEAT is allowed to be > 0.

2 CAN_H and CAN_L signals on the CRO

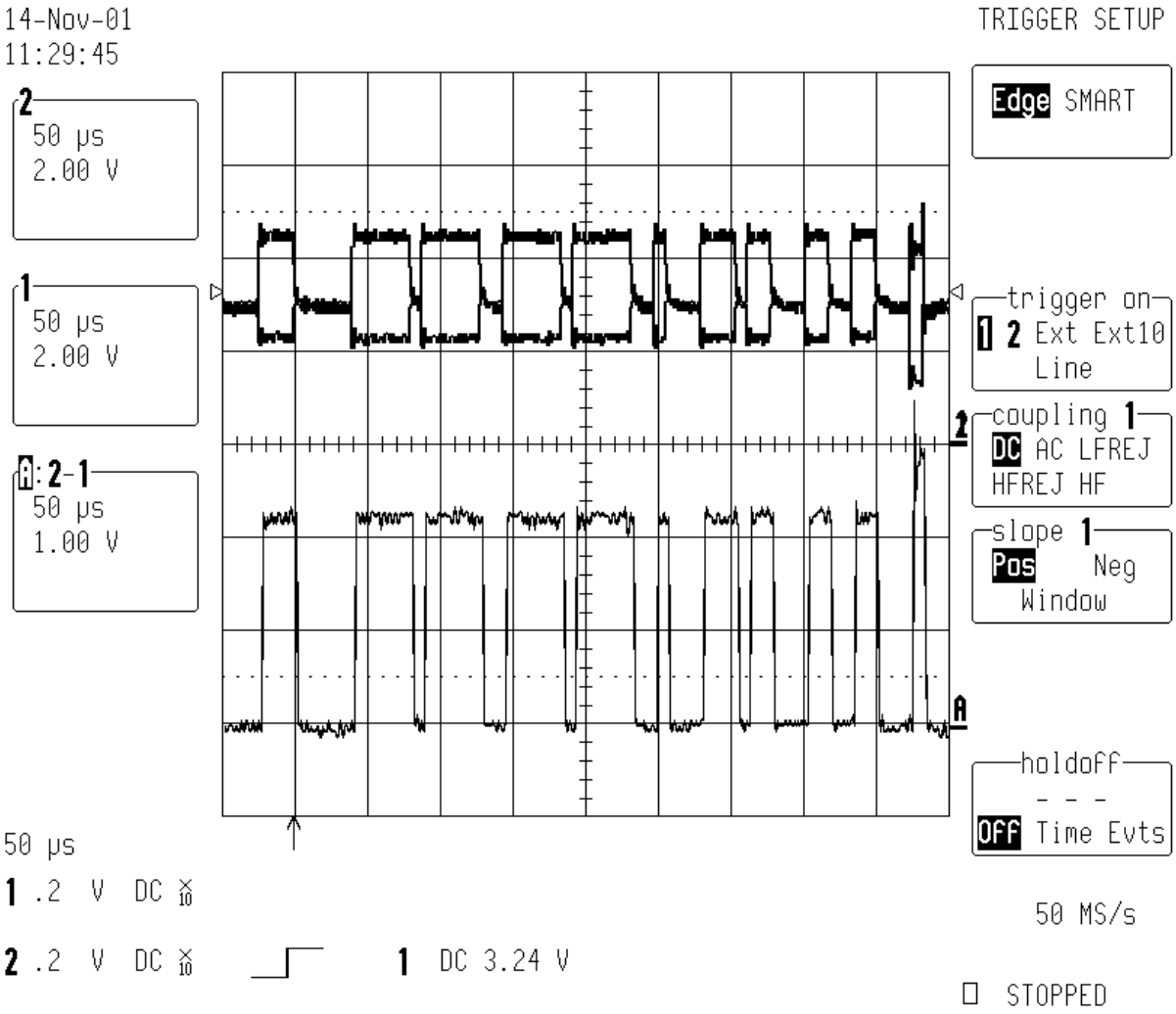


Figure 1. CAN bus signals on the CRO.

In the figure above CAN_H (channel 1), CAN_L (channel 2) signals and their difference (calculated channel A) are shown. With a dominant signal the difference between CAN_H and CAN_L must be more than 1.5 Volt (1.5 to 3 Volt according to the line driver data sheet). With a recessive signal the difference voltage is equal to zero. The last difference signal in a CAN message is the so-called ACK signal and this is confirmed by all CAN modules on the bus. The difference voltage for the ACK signal is thus greater than the voltage for the previous signals.

This example was produced with a baud rate of 125 kBit. The storage CRO used was a LeCroy with a 2.5 Gbit sampling rate. The setting for the voltage level and the triggering can be seen in the figure.

3 Measuring the wiring and screening

3.1 Measuring the wiring

The following measurements are made using a suitable Ohmmeter (measuring range < 200Ω) between two CAN connectors on the ends of the cable.

CAN_24V Pin 1 at the start of the cable to pin 1 at the end of the cable
CAN_L Pin 2 at the start of the cable to pin 2 at the end of the cable
CAN_0V Pin 3 at the start of the cable to pin 3 at the end of the cable
CAN_H Pin 4 at the start of the cable to pin 4 at the end of the cable

Measuring arrangement:

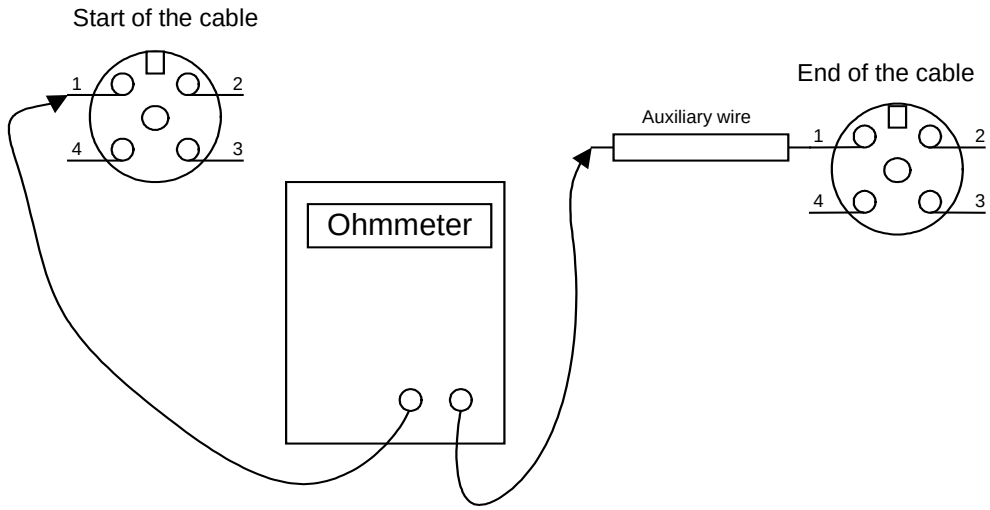


Figure 2. Measurement of the cable resistances

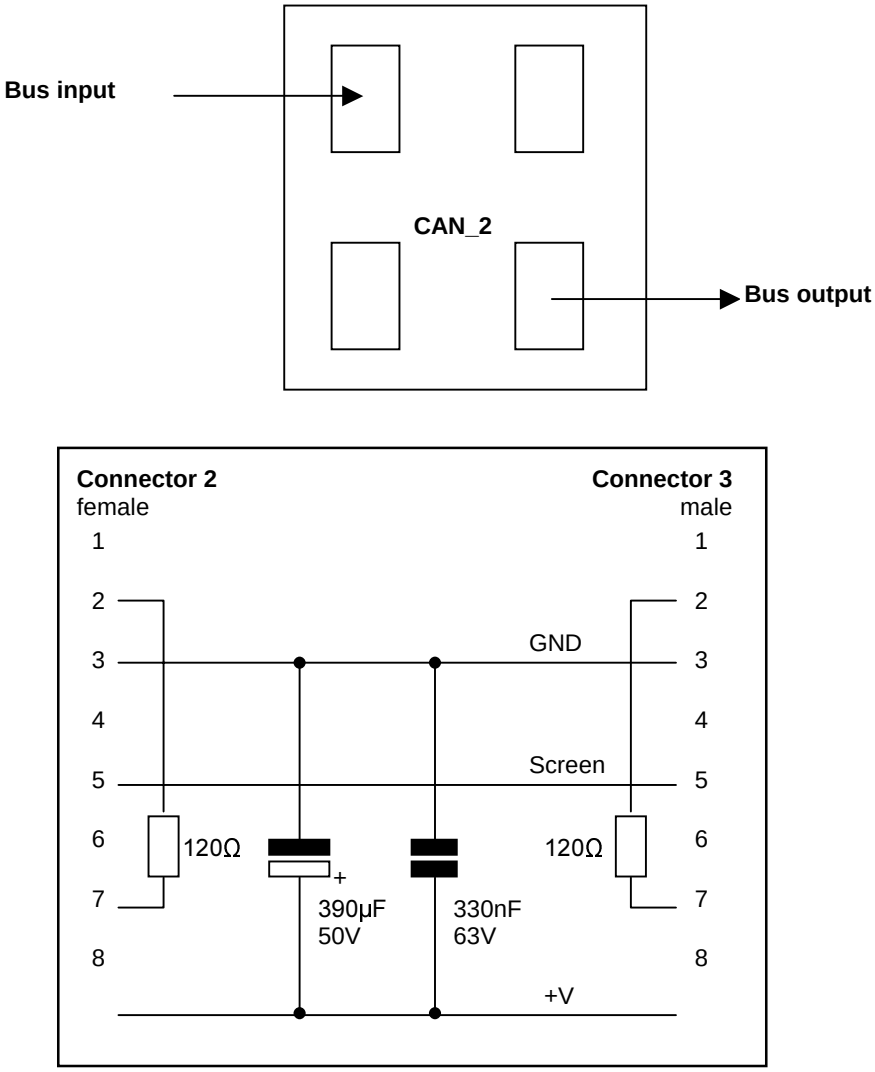
The resistance measured is the sum of the resistances in the connector (approx. 10-30 milliohm/connector) and the cable resistances. The CAN cable used has a resistance of around 160 milliohm/m. For a 30 m long cable, around 4.8 to 5.8 Ohm will be measured on the CAN_H and CAN_L wires depending on the number of modules.

It is to be noted that the CAN_H and CAN_L wires are only single wires and the CAN_0V and CAN_24V wires are duplicated; this results in the halving of the resistances of these wires.

If a CAN repeater has been used, the CAN_H and CAN_L wires should be measured before and after the repeater because the repeater electrically isolates these wires. The CAN_0V and CAN_24V wires bridge the repeater.

3.2 CAN repeater

The electrically isolating CAN repeater transmits and amplifies the CAN signals. The bus input and bus output wires are each terminated with a 120Ω resistor (D-SUB-9 pin 2 to pin 7). The CAN_0V and CAN_24V wires and the screen are wired through directly and reservoir capacitors are arranged between the CAN_0V and CAN_24V wires.



Pin	Identifier	Function
2	CAN_L	CAN data wire → dominant low
3	CAN_0V	Ground
7	CAN_H	CAN data wire → dominant high
9	CAN_24V	Positive supply +24V

Figure 3. CAN repeater

3.3 Measuring the terminating resistors

Measuring arrangement:

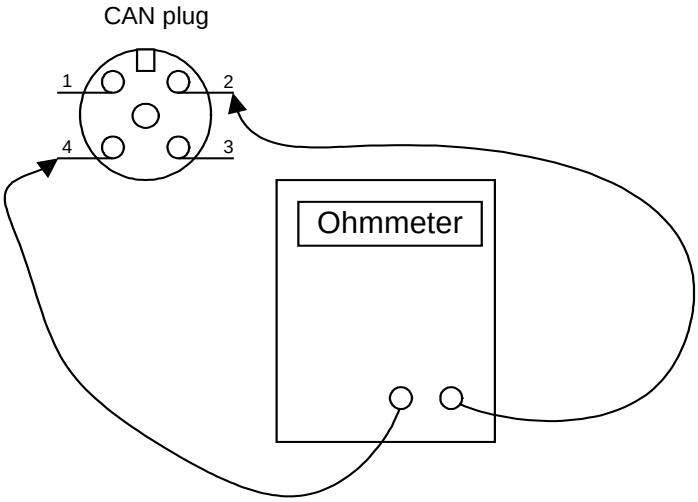


Figure 4. Measurement of the terminating resistors

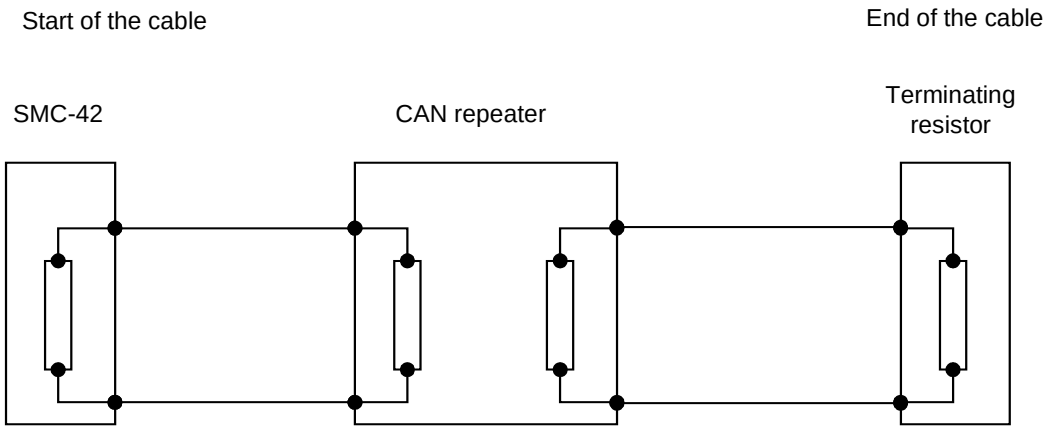


Figure 5. 120Ω terminating resistors

The terminating resistors at the ends of the wires are 120Ω.
On a measurement with a CAN repeater approx. 60 Ohm will be measured on the bus input and bus output if the CAN circuit is not open.

All measurements must be made with the system switched off.

3.4 Measuring the screening

The error that occurs most frequently is inadequately tightened CAN connectors on the modules, or that the cable fitting on the connector for connecting the screen is not tight enough.

The measured resistance between the CAN bridges from one module to another should be less than 0.4 Ohm.

Figure 5. Measuring the screening

If the resistances measured are higher, you should tighten the connector on the CAN cable.

Good screening significantly increases the immunity of the CAN I/O bus to interference.

4 Known problems and solutions

For the CAN I/O bus to function correctly, several prerequisites must be met.

1) The declarations for the CAN I/O modules in the SMC-42 program must be made in the same order as they are wired.

2) The declaration for the baud rate must be the same in all modules.

3) The CAN cable must be screened, the CAN connector on every module tightened and a connector with the terminating resistors must be fitted at the end of the bus on the last module.

Despite these measures defective cables, CAN I/O modules, missing terminating resistors or poor screening can cause problems.

4.1 SMC-42 program

The SMC-42 program is checked by the compiler to ensure that no inputs or outputs can occur in the program that are not declared as local and extended inputs and outputs (Extension I/O) or as CAN I/O inputs and outputs. With one exception (bracketing out of the modules with the "<" operator, or the usage of the command CAN_CHECK 0) the CAN I/O modules are also continuously monitored for their presence. The most important language elements are:

```
BIT_RATE
.LIMITS
.CAN_DEVICE, .END_CAN_DEVICE
CAN_ON, CAN_OFF
CAN_CHECK
```

The significance of these commands can be found in the SMC-42 manual. A brief explanation follows.

4.1.1 Baud rate declaration

At the start of the SMC-42 program the baud rate on the CAN I/O bus must be declared.

Example:

```
BIT_RATE  125k
```

All modules must be pre-programmed for this baud rate. The CAN I/O bus cannot be started if this condition is not met.

4.1.2 .LIMITS declaration

Example:

```
.LIMITS   SMC1,I1001-1192,O1001-1192,F1001-2000,D1001-1320,
          CI1193-1872,CO1193-1872,T6,Z4,X5,Y6,S18,W44,J1024,G47
```

These include:

- I LOCAL INPUTS
- O LOCAL OUTPUTS
- CI CAN-BUS INPUTS
- CO CAN-BUS OUTPUTS
- G CAN-BUS DEVICES

4.1.3 .CAN_DEVICE declaration

For each individual module, the module number, the module type, the assignment of the first input and the first output must be specified in the SMC 42.

Example :

```
.CAN_DEVICE
ID1,T0,I0193,O0193
ID2,T0,I0201,O0201
ID3,T1,I0209,O0209
ID4,T1,I0217,O0217
..
ID127,T4,I0281,O0281          ;starter box
ID63,T2,I0287,O0287
...
ID56,T2,I0409,O0409
ID8,T2,I0441,O0441
...
.END_CAN_DEVICE
```

Comment :

ID1 is the module number 1,

T0 is the module type with 8 inputs and 4 outputs,
T1 is the module type with 4 inputs and 8 outputs,
T2 is the module type with 24 outputs,
T4 is the module type with 8 inputs and 8 outputs,

I0193 is the number for the first input on module 1,
O0193 is the number for the first output on module 1,

If the module type is incorrectly stated, the system error 51 (CAN modul_type error ID=) is triggered with the ID number.

On start up or troubleshooting on the CAN I/O bus, you can bracket out the modules that are not yet connected to the bus.

Example:

```
.CAN_DEVICE
ID1,T0,I0193,O0193
ID2,T0,I0201,O0201
<ID3,T1,I0209,O0209
<ID4,T1,I0217,O0217
..
<ID127,T4,I0281,O0281          ;starter box
<ID63,T2,I0287,O0287
...
<ID56,T2,I0409,O0409
<ID8,T2,I0441,O0441
…
.END_CAN_DEVICE
```

The character "<" inserted at the start of the line allows the inputs and outputs to be used in the SMC-42 program without the generation of error messages by the compiler, however the bracketed out modules are not taken into account when starting up and operating the CAN bus. In this way it is possible to place individual modules in operation one after the other, or in the case of electrical problems, to switch in individual cables and modules in succession.

For this reason it is strongly recommended to list the modules in the .CAN_DEVICE program block in the order in which they are actually wired.

4.1.4 CAN_ON and CAN_OFF commands

These commands are used for switching on and off the CAN I/O bus. If a module is missing, the system error 59 (CAN missing modul at ID=) is triggered immediately with the ID number.

4.1.5 CAN_CHECK command

Using this command the frequency of the periodic check on all CAN I/O modules is defined.

Example:

```
CAN_CHECK 5
CAN_ON
```

On the failure of a module while the bus is in operation, the system error 53 (CAN timeout error at ID=) is triggered with the ID number.

4.2 System error 58

The causes are:

- Defective drivers on the front panel of the SMC-42
- No modules are connected
- Incorrect baud rate
- Short-circuit or open-circuit on the bus

The system error message 58 indicates the CAN I/O bus error status in which the error status of the status register in the 82527 controller is reflected.

BIT	7	6	5	4	3	2	1	0
Name:	BOff	Warn	Wake	RXOK	TXOK	LEC2	LEC1	LEC0

Table 1. Status register for the 82527 CAN controller

The significance of the individual bits is given in detail in the data sheet on the 82527. An abbreviated version of the significance of the bits in the system register follows:

BITS	NAME	Significance
7	BOff	0 = CAN bus is switched on 1 = CAN bus is switched off because of more than 256 errors
6	Warn	0 = less than 96 errors on the CAN bus or none 1 = warning, more than 96 errors on the CAN bus
5	Wake	sleep mode switchover
4	RXOK	1 = last message received without errors
3	TXOK	1 = last message sent without errors
0-2	LEC0-2	0 = no error 1 = stuff error (more than 5 bits the same in the message) 2 = shape error (incorrect format of the message received) 3 = Ack error (no CAN I/O module has received and acknowledged the message sent) 4 = bit 1 error (it was not possible to send the last message) 5 = bit 0 error (own message read incorrectly) 6 = checksum error

Table 2. Bits in the status register in the 82527 CAN controller

Example:

```
p_index = 00000000     CAN_OFF
STOP at system error NR: 58
CAN 8257 error status =
STATUS = 43HEX 67
```

The STATUS 43HEX signifies that the bits 6, 1 and 0 (=3) are high. The 3 indicates an ACK error if, e.g., there is no CAN I/O module connected to the bus.

4.3 Missing modules

Missing or incorrectly configured modules (type) are indicated with the system errors 59 or 51 when the CAN I/O bus is started.

4.4 Malfunction or short-circuit on the output of a module

If there is a short-circuit on the output of a module, or in the event of synchronisation problems on the CAN I/O bus, error signals from the individual modules are received in SMC_42, this results in system error 52 after more than 8 error messages from the same module in succession. In the case of occasional error messages, a system error is not triggered. However, the error messages are totalled for each module and appear in the error statistics.

4.5 Short-circuit on the input of a driver

Such an error can only be detected with the CRO. In this case one of the two difference signals CAN_H or CAN_L is short-circuited. The consequence is an accumulation of error signals from the CAN modules that have problems with synchronisation. The module with the faulty driver is identified using a modified SMC-42 program in which, e.g., all modules except for the first two are bracketed out. The terminating resistor is connected to the second module and then the CRO image should correspond to the signal curve shown in Figure 1. Further modules are then connected electrically until the faulty module is found. Only when all other modules except the faulty module are re-connected and the CRO signal corresponds to that in Figure 1, can the faulty module be replaced with certainty.

4.6 Summary of the system error messages

The SMC42 operating system generates the following system error messages.

No.:	Error message	Significance
51	CAN modul_type error ID=	Incorrect module type declared in CAN_DEVICE
52	CAN error message at ID=	Malfunction in the CAN I/O module or short-circuit
53	CAN timeout error at ID=	CAN I/O module no longer responds
54	CAN unknown modul at ID=	Module not declared in CAN_DEVICE
55	CAN return error at ID=	Incorrect message from CAN I/O module
56	CAN transmt buf overflow	Transmit buffer full
57	CAN receive buf overflow	Receive buffer full
58	CAN 82527 error status =	CAN I/O bus error status
59	CAN missing modul at ID=	Missing CAN I/O module
61	wrong CAN identifier	Missing CAN I/O module

Table 3. Error messages

5 Filtering the CAN messages after a system error

In the case of a system error on the CAN I/O bus, from SMC-42 system version 8 the most recent messages can be viewed in plain text and various filters used.

After the system error message, first one of the arrow keys, HIGH or LOW key is pressed to display blocks of 12 messages in steps of 1, 10 or 100. A number between 0 and 5 is then entered for the filtering. On the entry of the number 0, mode 0 is selected. Here all CAN messages are displayed in plain text as previously.

If a number between 1 and 4 is selected, the ID (numbers 1 to 127) for the module to be found must be entered and confirmed with "=". Then only the CAN messages from and to the CAN I/O module with this ID are filtered. To display these messages one of the arrow keys, HIGH or LOW key must be pressed again.

If the number 5 is entered then the error messages for all modules are displayed.

The following table shows the allocation of the filter properties.

Mode	Filter
0	none
1	ID, all messages
2	ID, input messages
3	ID, output messages
4	ID, error messages
5	all error messages

The CAN message filter is very recommendable to ensure that modules are not replaced unnecessarily due to error messages from them as a consequence of other errors that have occurred on the CAN I/O bus.